# Space Weather Technical Forecast

Issued on Sunday, 10 March 2024 at 01:26 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Slight chance of G1/Minor Storms, especially 10 and 11 March due to CME arrivals or high speed stream connections. Chance of M-class flares throughout.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low with a peak C6.3 flare from AR3599 at 09/0119UTC. Generally activity has been at a C-class background with no further significant flares. There are six sunspot regions on the visible disc, with AR3599 (Dai/βγδ) the largest and most complex region, located in a southwest quadrant. The remaining regions are all simple or fading, with no significant flare activity.

No Earth directed CMEs have been observed in coronagraph imagery. A CME to the southwest will be analysed once sufficient imagery is available. A further CME to the northeast of satellite imagery appears to be from beyond the northeast limb and therefore not to be Earth-directed, but will be analysed.

**Solar Wind / Geomagnetic Activity:** Solar wind parameters observed by ACE at L1 showed signs of a slightly elevated solar wind environment, with speeds around 400-500km/s. Density has been below average. Total magnetic field strength, IMF has been weak throughout, below 6nT, with the north-south component varying weakly between +4nT and -5nT. Phi angle has been positive (away from the Sun) throughout. Geomagnetic activity started Active between 09/0000-0300UTC, but has been Quiet to Unsettled since.

**Energetic Particles / Solar Radiation:** GOES18 high energy (greater than 10MeV) proton flux was at background levels.

High energy electron flux (greater than 2MeV) observed at GOES16 rose from background to mainly moderate levels with a peak at 427pfu at 09/1545UTC. The associated 24 hour fluence well below the Active (1e8 integrated pfu) threshold. The observed 24-hour fluence at 10/0000 UTC was 1.18e7 integrated pfu.

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# Met Office Space Weather Technical Forecast

**Four-Day Space Weather Forecast Summary**
**Solar Activity:** A chance of M-class flares through the period, mainly due to AR3599, with a flat trend due to no significant regions joining or leaving the disc in the next four days.

**Solar Wind / Geomagnetic Activity:** Two CMEs could potentially arrive at Earth through the forecast period. The first feature was due to arrive on 09 March, but with a small risk of arrival early on 10 March, although with decreased confidence. A second CME is forecast to arrive on 11 March, although confidence is low in timing and potential impacts.

A high speed stream, with speeds of 400-500km/s from coronal hole 06 may decline by around 11 March, with a further coronal hole high speed stream potentially connecting in the same period. Speeds from this feature are also estimated to be around 400-500km/s. Geomagnetic activity is expected to be Quiet to Unsettled. There is a risk of Active to G1/Minor Storm intervals from either the CME arrivals or the possible onset of the coronal hole high speed stream on 10 or 11 March.

**Energetic Particles / Solar Radiation:** GOES18 high energy proton flux is expected to persist at background levels. GOES16 high energy electron flux is expected to remain at mainly moderate levels, with an increasing risk of exceeding the high threshold on diurnal peaks, subject to complicating effects from CME arrivals. Electron fluence is forecast to be below the Active threshold but with a rising trend.

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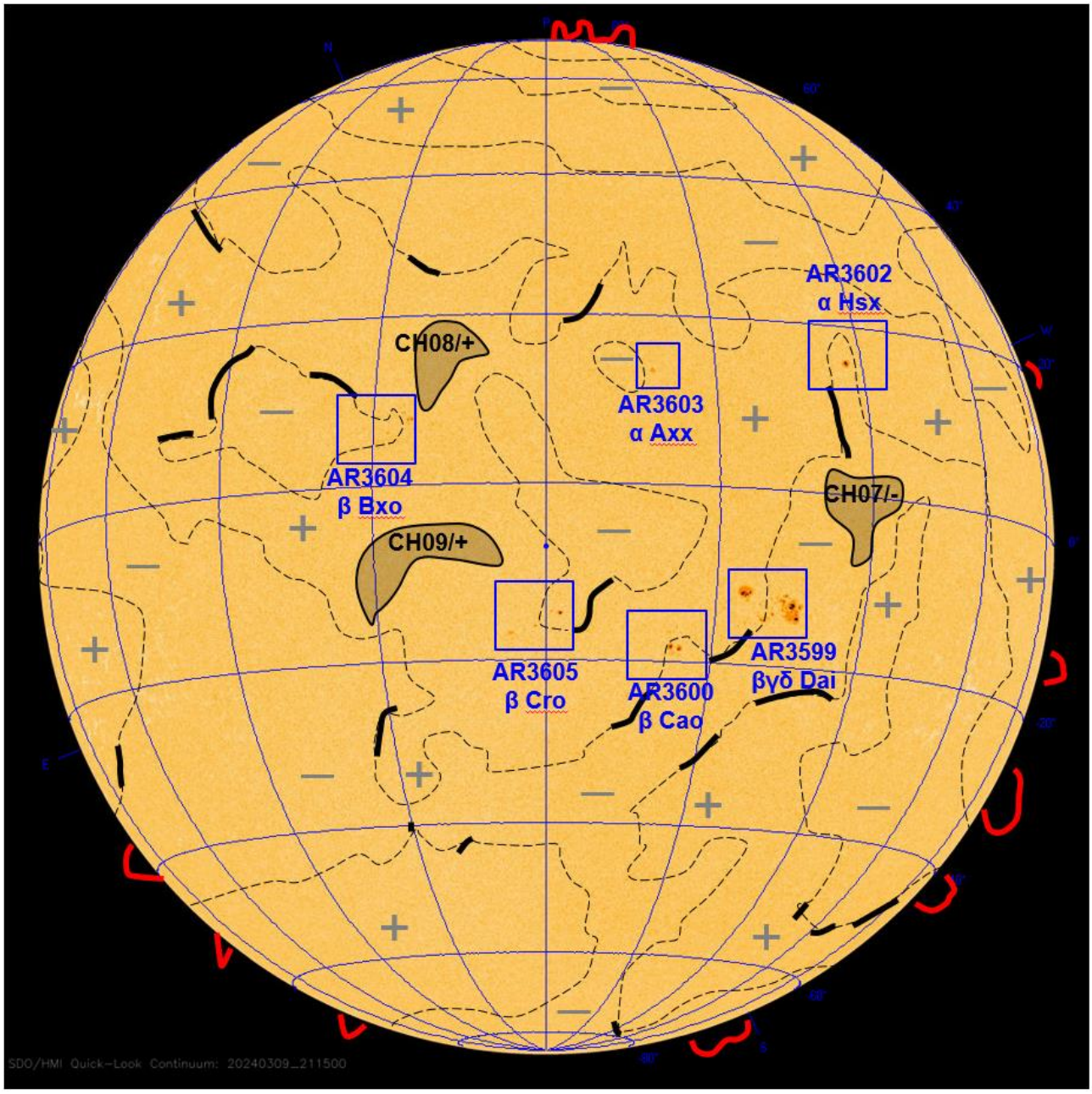
**Figure 1. Solar Analysis Valid 09/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

Two CMEs are forecast to potentially affect the Earth through the forecast period. The first, which left the Sun 05 March was due to arrive at earth early on 09 March, and although this now appears to be late there is still a chance of a late arrival into early on 10 March. A CME from 07 March may then arrive on 11 March, with a similar level of confidence. The arrival times are based on the Enlil model, with wind speeds overestimated, leading to the probability of later arrivals.

Otherwise the Earth is under the influence of a high speed stream from coronal hole 06 which likely to continue to affect the Earth through to around 12 March, with continuing speeds of between 400-500km/s. Coronal hole 07 may then connect on either 10 or 11 March dependent on speed from this non-recurrent feature, with estimated speeds of 400-500km/s through to the end of the forecast period. However as this is a newly developed feature there is high uncertainty in development and potential impacts.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled. There is a risk of Active to G1/Minor Storm intervals due to the potential CME arrivals. There is a risk that the onset of any high speed stream from coronal hole 07 could lead to further Active or G1/Minor Storm intervals dependent on any CIR ahead of the connection, especially as the hole is of a positive polarity. Positive polarity holes are favoured for a strong connection close to the March equinox.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 10 | 20 | 5 | 5 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 06/0210 | Partial | Filament | SE | 790 km/s | 09/0001 UTC | Overdue. Glancing blow possible. |
| 07/2215 | Partial | Filament | NW central | 450 km/s | 11/0600 UTC | Low confidence. Glancing blow possible. |

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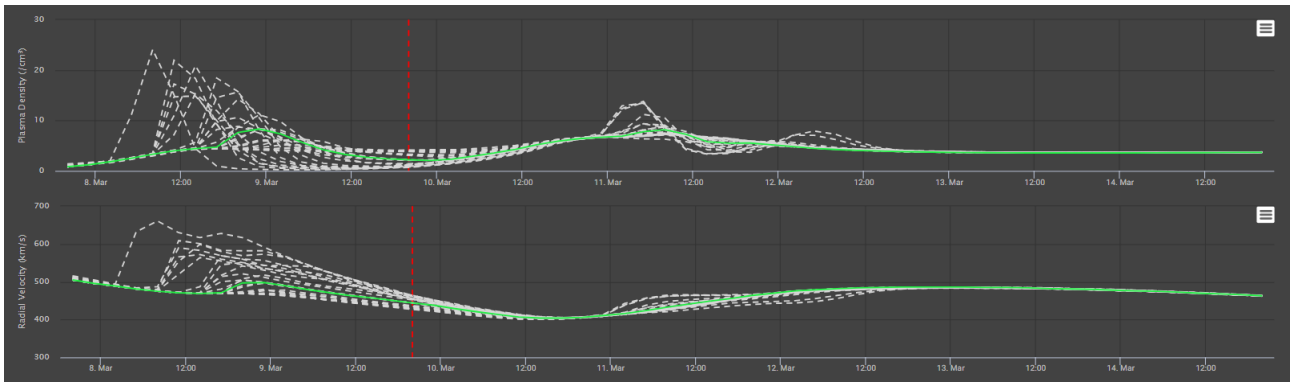
**Figure 2: MOSWOC Enlil ensemble, showing the main risk periods for the two forecast CME arrivals.**



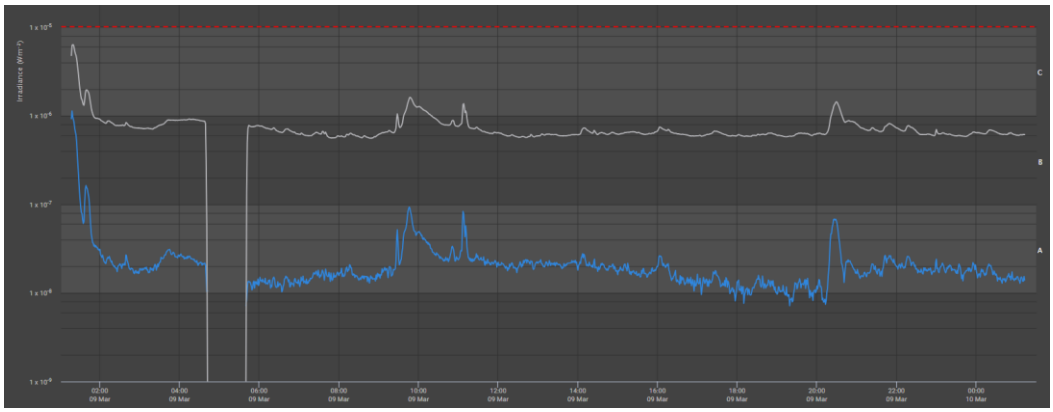

## Radio Blackouts - X-Ray Flares:

AR3599 is the largest and most complex region on the visible disc, with a βγδ configuration. This has produced one C-class flare, but this configuration presents a risk of M-class flaring despite the recent history. The remaining regions are all weak or fading.

Solar activity is expected to be mainly Low, with a chance of M-class flaring.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 20 | 20 | 20 | 20 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

**Figure 3: GOES 16 X-ray flux**



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## Solar Radiation Storms - (High Energy Protons):

GOES18 proton flux is currently at background. However, we may see a slight chance of reaching S1 levels, if any significant flaring occurs from AR3599, especially given the complex configuration as it continues to rotate towards the geoeffective region of the western hemisphere in the coming days.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 5 | 5 | 5 | 5 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has increased from background to mainly Moderate levels in the slightly elevated solar wind environment due to the high speed stream from coronal hole 06. This high speed stream is expected to input electrons into the radiation belts, and with speeds around 450km/s, there is likely to be only limited distortion of the belts, with steady build of electron flux, and an increasing risk of exceeding the high threshold through the period. There is also a risk of two CME arrivals, one due on 09 March and one on 11 March, and should either of these arrive, they could complicate the forecast with a consequential distortion of the radiation belts and increase in the geomagnetic activity initially redistributing any electrons.

In the absence of any CME arrivals, the electron fluence is expected in rise, with an increasing risk of reaching the Active (1e8 integrated pfu) by the end of the period.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 10 | 10 | 10 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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